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Description

FIELD OF THE INVENTION

This invention relates to fuel cells. More particularly, this invention pertains to novel fluid flow field plates used in solid polymer electrolyte fuel cells.

BACKGROUND OF THE INVENTION

A fuel cell is a device which generates electrical energy by converting chemical energy, derived from a fuel supplied to the cell, directly into electrical energy by oxidation of the fuel in the cell. A typical fuel cell includes a casing which houses an anode, a cathode and an electrolyte. Appropriate fuel material and oxidant are supplied respectively to the anodes and cathodes, the fuel and oxidant react chemically to generate a useable electric current, and the reaction end product is withdrawn from the cell. A relatively simple type of fuel cell involves use of hydrogen and oxygen as the fuel and oxidant materials, respectively. The hydrogen combines with the oxygen to form water while at the same time generating an electrical current. More specifically, hydrogen is consumed at the fuel cell anode releasing protons and electrons as shown in equation (1) below. The protons are injected into the fuel cell electolyte. The electrons travel from the fuel cell anode to the anode terminal, through an electrical load, back to the cathode terminal, and into the cathode of the cell. At the cathode, oxygen, electrons from the load and protons from the electrolyte combine to form water as shown in equation (2) below.

Anode Reaction

$$H_2 \rightarrow 2H^+ + 2e \quad (1)$$

Cathode Reaction

$$\tfrac{1}{2}O_2 + 2e + 2H^+ \rightarrow H_2O \quad (2)$$

A great advantage of a fuel cell is that it converts chemical energy directly to electrical energy without the necessity of undergoing any intermediate steps, for example, combustion of a hydrocarbon or carbonaceous fuel as takes place in a thermal power station.

Fuel cell can be classified into several types according to the electrolyte used. Modern relatively high performance fuel cells include electrolytes such as aqueous potassium hydroxide, concentrated phosphoric acid, fused alkali carbonate and stabilized zirconium oxide. the electrodes invariably include a catalyst for promoting the reactions that take place on respective electrodes in the fuel cells. Suitable catalysts include nickel, silver, platinum and, in the case of the stabilized zirconium oxide electrolyte, base metal oxides.

General Electric in the 1960's commenced work on the development of a solid polymer fuel cell (SPFC). Such a cell had a number of potential advantages. It could operate on a hydrogen containing fuel and an oxidant feed such as air or pure oxygen. In one embodiment, the SPFC could operate on reformed hydrocarbons such as methanol or natural gas as the fuel source and air as the oxidant.

Since the electolyte in a SPFC is solid, substantial pressure differences between the fuel and the oxygen streams can be tolerated. This simplifies pressure control and, in particular, allows for higher pressures to exist in the oxidant stream. This leads to increased performance, particularly when air is used as the oxidant. An SPFC is advantageous in that it can be operated at temperatures below the boiling point of water at the operating pressure. Accordingly, water as the end product is generated in the liquid state.

More specifically, a typical SPFC uses a solid polymer ion exchange membrane as electrolyte between the anode and cathode. The solid polymer ion exchange membrane permits the transmission through the membrane of hydrogen ions, but is substantially impervious to the passage of hydrogen and oxygen molecules. The ion exchange membrane has thereon negatively charged sites chemically attached to the polymer. The ion exchange membrane is sandwiched between the anode and cathode. Typically, a platinum catalyst is added to the anode and cathode to increase the rate of reaction.

In a single cell arrangement, two fluid flow field plates (anode and cathode plates) are provided. The plates act as current collectors, provide electrode support, provide means for access of the fuel and oxidant to the anode and cathode surfaces, respectively, and provide for removal of water formed during operation of the cell.

The cell assembly is held together by tie rods and end plates. Feed manifolds are respectively provided to feed the fuel (hydrogen, reformed methanol or natural gas) to the anode and the oxidant (air or oxygen) to the cathode via the fluid flow field plates. Exhaust manifolds are provided to exhaust excess fuel and oxidant gases and water formed at the cathode. Multi-cell structures comprise two or more such sandwich combinations connected together in series or in parallel to increase the overall power output of the assembly as required. In such arrangements, the cells are typically connected in series, wherein one side of a given plate is the anode

plate for one cell, and the other side of the plate is the cathode plate for the adjacent cell and so on.

DESCRIPTION OF THE PRIOR ART

A typical prior art fluid flow field plate includes in a major surface thereof a plurality of separate parallel open-faced fluid flow channels cut out of said major surface. The channels extend across the major surface between a feed fluid inlet and an exhaust outlet. The channels are typically of rectangular shape in cross-section, being about 0.03 inches deep and about 0.03 inches across the opening. The inlet is connected to a fuel or oxidant feed. In multi-cell arrangements both major plate surfaces may include flow channels. In operation, the flow channels supply fuel or oxidant to the electrode surface from the inlet. This prior art is exemplified by General Electric and Hamilton Standard LANL No. 9-X53-D6272-1 (1984).

It was found that when running the cell on air for extended periods of time that low and unstable voltages resulted. The problem was traced to the cathode side of the cell and specifically to cathode gas flow distribution and cell water management.

Specifically, when the fuel cell is operating continuously, that is, it is producing electric current and consuming fuel and oxygen on a continuous basis, liquid water is continuously produced at the cathode. Unfortunately, with this prior art plate, it has been found that the water formed at the cathode accumulates in the channels adjacent to the cathode. It is believed that as the water accumulates, the channels are wetted and the water thus tends to cling to the bottom and sides of the channels. The water droplets also tend to coalesce and form larger droplets. A force, which increases with the size and number of the droplets, is required to move the droplets through the channel. In the flow field of the prior art, the number and size of the water droplets in parallel channels will likely be different. The gas will then flow preferentially through the least obstructed channels. Water thus tends to collect in the channels in which little or no gas is passing. Accordingly, dead spots tend to form at various areas throughout the plate. It was therefore concluded that poor performance was caused by inadequate drainage of product water which results in poor gas flow distribution on the cathode side.

In the 1970's, General Electric manufactured and sold a 12 watt power generating unit under the trademark, "PORTA-POWER". This unit included a plastic coated aluminum plate (non-electrically conductive) which had on one side (the hydrogen side) a single relatively wide 0.635 cm (0.25 ins) traversing groove. This plate did not act as a current collector. Also, since the anode (hydrogen) side had the single groove, it was not for the purpose of conveying water from the unit i.e. product water is formed only on the cathode (oxygen) side. Furthermore, in the GE unit, the current collector was a Niobium metal screen (with electrical contact made at the edge of the electrode).

Another variation of the prior art flow field is described in U.S. Patent No. 4,769,297 of 6 September 1988 in the names of Carl A. Reiser et al. This reference describes a "waffle iron" flow field which involves a plurality of discontinuous fluid flow paths. Water is managed by use of porous flow field plates and hydrophillic separator plates. A pressure difference between the oxygen and hydrogen flow fields forces the water to flow out from the cell.

According to the invention a solid polymer electrolyte fuel cell is provided in which, during use, liquid water is produced, including a fluid flow field plate made of a suitable electrically conducting material and having an open-faced fluid flow channel, a fluid supply opening and a fluid exhaust opening formed in a major surface thereof;

characterised in that the plate includes multiple continuous fluid flow channels, each said channel traverses a major central area of said surface in a plurality of passes and has a fluid inlet at one end directly connected to said fluid supply opening and a fluid outlet at the other end directly connected to said fluid exhaust opening and each said channel includes a hydrophobic coating thereon, so that water produced during operation of the cell is urged through the fluid flow channels towards said fluid exhaust opening under pressure of the fluid in the channels.

The channel may follow a serpentine traversing path.

Advantageously, the channel traverses the major surface of the plate in a plurality of alternating closely spaced longer and shorter passes.

A channel may be formed in both major surfaces of the plate.

The plate may be a rigid non-porous graphite plate.

Advantageously, the channel comprises a base and opposing side walls diverging outwardly from said base toward said open-face. The base of the channel may be flat.

The channel may be of uniform depth throughout the length of the channel.

The hydrophobic coating may be selected from the group consisting of polytetrafluoroethylene and silicone.

The fluid flow plate advantageously, comprises multiple separate continuous open-faced fluid flow channels, each channel having its own respective fluid inlet and outlet.

Advantageously, the fluid flow plate further includes a fluid supply opening defined in said surface, each said fluid inlet and outlet of said multiple channels being directly connected to said fluid supply opening and to said fluid exhaust opening, respectively.

The major central area of the plate may be recessed to accommodate an electrode of said fuel cell. Opposing plates in said fuel cell may include matching recesses.

Advantageously, said major surface, adjacent channel passes are separated by lands. The lands are of a width less than the width of the open face of the channel.

In a preferred embodiment of the invention, the width of the open-face of the channel is in the range of 0.076 to 0.610 cm (0.030 to 0.240 inches), and may be in the range of 0.102 to 0.254 cm (0.040 to 0.100 inches), and is advantageously in the range of 0.114 to 0.140 cm (0.045 to 0.055 inches), and is preferably about 0.127 cm (0.050 inches).

In a preferred embodiment of the invention the land width is in the range of 0.025 to 0.508 cm (0.010 to 0.200 inches), and may be in the range of 0.051 to 0.254 cm (0.020 to 0.100 inches), and is advantageously in the range of 0.089 to 0.140 cm (0.035 to 0.055 inches), and is preferably about 0.102 cm (0.040 inches).

The suitable electrically conducting material may be selected from the group consisting of graphite; a corrosion-resistant material, advantageously niobium; a base metal plated with a corrosion resistant metal; and a composite material composed of a corrosion-resistant metal powder, a base metal powder plated with a corrosion resistant metal or other chemically inert electrically conducting powders, advantageously 10-30%/w of polyvinylidene fluoride and 90-70%/w of graphite powder, bonded together with a suitable binder, advantageously polyvinylidene fluoride.

In a preferred embodiment of the invention, the channel depth is in the range of 0.025 to 0.635 cm (0.010 to 0.250 inches), and may be in the range of 0.076 to 0.381 cm (0.030 to 0.150 inches), is advantageously in the range of 0.102 to 0.203 cm (0.040 to 0.080 inches), and is preferably about 0.127 cm (0.050 inches).

According to the present invention there is further provided a solid polymer electrolyte fuel cell of the kind described above, the fuel cell further comprising:

an anode;

a cathode, and

a solid polymer electrolyte sandwiched between said anode and cathode; and wherein

an opposing pair of said fluid flow field plates are arranged in respective operative association with said anode and cathode, one of said field plates having a first fluid flow field adjacent said anode for supplying fuel thereto and exhausting reaction products therefrom, and the other of said field plates having a second fluid flow field adjacent said cathode for supplying an oxidant thereto and exhausting reaction products therefrom.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

Figure 1 is a side elevation in section of an electrode assembly of the present invention;

Figure 2 is a plan view of a fluid flow field plate showing one embodiment of a continuous traversing groove in the plate;

Figure 3 is an end section detail of Figure 2 showing the groove on an enlarged scale; and

Figure 4 is a plan view of a fluid flow field plate used in the present invention having multiple flow channels each directly connected at inlet and outlet ends thereof to supply end exhaust openings, respectively, according to another embodiment of this invention.

DETAILED DESCRIPTION OF THE PREFERRED EXEMPLARY EMBODIMENTS

Referring to the drawing, as seen in Figure 1, an electrode assembly 10 is supported between a pair of rigid fluid flow field plates 12 and 13. The electrode assembly 10 is located in central matching recesses 14 provided in opposing major plate surfaces 15, and includes an anode 16, a cathode 18 and a solid polymer electrolyte 20 sandwiched between the anode and cathode. It will be appreciated that a single recess could be provided in either of the plates to achieve the same result.

The fluid flow field plates are made of a suitable electrically conducting material. A rigid, non-porous graphite plate has been found useful for most applications. Graphite is preferred because it is chemically inert in the environment used and inexpensive. Other suitable materials include corrosion resistant metals such as niobium, less corrosive resistant base metals such as magnesium or copper when plated with noble metals such as gold or platinum to render them unreactive and a composite material composed of a corrosion-resistant metal powder, a base metal powder plated with a corrosion-resistant metal, or other chemically inert electrically

conducting powders, such as graphite, boron carbide, etc., bonded together with a suitable polymeric binder to produce a conducting plate.

Suitable polymeric binders include thermoplastic resins suitable for injection molding such as Kynar, a trademark for a polyvinylidene fluoride material manufactured by Penwalt.

Typical composites include 90-70% high purity graphite powder and 10-30% of polyvinylidene fluoride.

As best seen in Figure 2, major plate surface 15 has formed therein (typically by numerically-controlled machining, stamping, or molding) a single continuous fluid flow channel 22, said channel having a fluid inlet 24 at one end and a fluid outlet 26 at the other end. The fluid inlet 24 is directly connected to a fluid supply opening 25 in the plate, and the fluid outlet 26 is directly connected to a fluid exhaust opening 27 in the plate.

The open-face 23 of the channel extends along its entire length. The fluid opening is connected to a source of fuel (not shown) for the plate adjacent the anode or a source of oxidant (not shown) for the plate adjacent the cathode. It is seen that the channel 22 traverses in a plurality of passes a major central area of the plate 12, corresponding to the area of the anode or cathode to which it is adjacent when assembled. In the embodiment illustrated, the channel follows a serpentine path. Non-serpentine channel arrangements may be used, provided that they are continuous. To maximize the coverage of the electrode surface, the channel traverses the plate in a plurality of alternating longer and shorter closely space passes. Preferably the plates are arranged such that the longer passes of one plate are disposed substantially at right angles to the longer passes in the opposing plate. This is to eliminate the difficulties in matching opposing plate surfaces and to permit the use of different flow field structures on opposing plates.

In Figure 3, the channel is illustrated in cross-section. The channel 22 is seen to be defined by a flat base 29 and opposing sidewalls 30 which diverge outwardly from the base toward the open-face 23. The shape of the channel is generally not critical. For example, the base could be rounded to form a U-shaped channel. The channel is shaped as illustrated to minimize tool wear. Preferably, the channel is of uniform depth throughout its length. A design in which the sidewalls converge toward the open-face would be less desirable. A series of substantially parallel lands 32 is thus defined between the longer channel passes. This design also enhances accurate machining of the channel.

When assembled, the lands 32 between the channels on the plate adjacent the anode are in contact with the anode and the lands 32 between the channels on the plate adjacent the cathode are in contact with the cathode. Accordingly, the electrically conducting plates also function as current collectors.

In general, the width of the open-face of the channel is in the range of 0.076 to 0.610 cm (0.030 to 0.240 inches). A preferred range is 0.102 to 0.254 cm (0.040 to 0.100 inches); the most preferred range being 0.114 to 0.140 cm (0.045 to 0.055 inches). For most applications, an open-face width of about 0.127 cm (0.050 inches) has been found acceptable.

We also find it desirable that the open-face of the channel is somewhat wider than the lands. Generally, land widths in the range of 0.025 to 0.508 cm (0.010 to 0.200 inches) are contemplated. A preferred range is 0.051 to 0.254 cm (0.020 to 0.100 inches); the most preferred range being from 0.089 to 0.140 cm (0.035 to 0.055 inches). We typically use a land width of about 0.102 cm (0.040 inches).

With regard to channel depths, we contemplate a range of 0.025 to 0.635 cm (0.010 to 0.250 inches). A preferred range is 0.076 to 0.381 cm (0.030 to 0.150 inches); the most preferred range being 0.102 to 0.203 cm (0.040 to 0.080 inches). The typical channel depth is about 0.127 cm (0.050 inches).

It will be appreciated that the aforementioned dimensions represent a compromise between electrochemical performance and the mechanical strength requirements for supporting the electrodes. Accordingly, the dimensions are variable within the stated ranges, depending upon the application.

The channels include a suitable hydrophobic coating thereon, to reduce wetting effects. Suitable hydrophobic coatings include polymers such as polytetrafluoroethylene and silicone.

In operation, the fluid flow field plate adjacent the anode supplies fuel, in this case hydrogen-rich gas, to the anode and the fluid flow plate adjacent the cathode supplies an oxidant (either pure oxygen or air) to the cathode. By employing a single continuous channel which traverses the plate and hence the adjacent electrode surface in a plurality of alternating longer and shorter closely spaced passes, access of adequate fuel and oxidant gases to substantially the entire anode and cathode surfaces, respectively, is assured.

As indicated above, because the operating temperature of the cell is below the boiling point of water at the operating pressure, and an immobile solid electrolyte is used, water formed as reaction product is expelled from the cathode into the gas stream as a liquid. Accordingly, in order to provide efficient cell performance, the liquid water must be removed as it is formed in order to avoid blocking of the channels (a prior art problem) which interferes with access of oxygen to the cathode. Applicant's novel continuous channel approach ensures that water formed is conveyed by gas flow through the channel and is exhausted from the cell. Accordingly, no dead spots can form at any point of the operating surface of the cathode due to water collection.

The present invention permits ready removal of water as it forms in the channel. In particular, the channel

design encourages movement of the water before it can coalesce to the point that a large water droplet forms and considerable force is then required to remove the formed droplet. The flow of the oxidant gas, typically oxygen, moves the water along the channel.

Moreover, when operating on air as the oxidant, the oxygen in the air is consumed, reducing the oxygen partial pressure in the air. The cell performance is sensitive to oxygen partial pressure. To compensate in part, the flow rate is increased when using air. Moreover, to have high, stable performance using air it is desirable to have as uniform an oxygen partial pressure along the entire length of the channel and hence across the cell, as possible. Since the achievement of uniform oxygen partial pressure is not practical, the next best thing is a uniform and controlled oxygen partial pressure drop across the cell. This can be accomplished using the fluid flow field plate of the present invention.

More specifically, since the air has a single channel to flow through it is thus uniformly distributed. Because the uniform distribution is sequential the oxygen concentration is the highest at the feed and falls linearly across the length of the flow channel. This is highly advantageous because the oxygen concentration at any point can be calculated or measured and thus controlled with accuracy.

EXAMPLES

Example 1. A fuel cell containing a cathode and an anode flow field plate of the prior art (i.e. the aforementioned General Electric separate parallel flow channel arrangement) and a standard membrane electrolyte/ electrode assembly, with an active electrode area of 0.0046 m^2 (0.05 ft^2), was operated on hydrogen and air at an air flow rate of 0.09 m^3/hr (3.18 ft^3/hr). After one hour of operation across a fixed resistive load of 0.0225 ohm, at a temperature of 54°C (130°F), the following performance was recorded.

Current Density	Cell Terminal Voltage (V)	Areal Power Density
3580 A/m^2 (333 A/ft^2)	0.417	1495 W/m^2 (139 W/ft^2)

Example 2. All experimental conditions were exactly the same as in Example 1 except that the cathode flow field plate was replaced with a flow field plate as shown in Figure 2. After one hour of operation, across the same fixed resistive load, the following performance was recorded.

Current Density	Cell Terminal Voltage (V)	Areal Power Density
4387 A/m^2 (408 A/ft^2)	0.500	2194 W/m^2 (204 W/ft^2)

It will be noted that the power available from the fuel cell has been increased by about 50%.

Thus, in the use of a single continuous pathway, for example, the serpentine traversing pathway illustrated in Figure 2, water is effectively removed from the cell by the maintenance of excess oxidant and hydrogen gas flows. Water may be produced on the hydrogen side due to condensation, or other factors, but the main water formation takes place on the oxidant side. As the water is produced, it is forced along the length of the pathway by the excess gas flow and expelled from the cell. Particularly with the single serpentine path, even if liquid water accumulates in the channel, the water is removed. Use of a single serpentine channel path also ensures that no "channeling" at any point in the operating area of the surface of the plate can occur, and dead spots are avoided because water is continuously flushed from the operating surface of the electrode. It will thus be appreciated that although water formation and uniform (controlled) oxygen access are problems which affect mainly the cathode side, the novel plate design is also useful on the anode side.

In multi-cell arrangements the other major surface of the plate may also include a continuous traversing channel. The two flow fields on opposite sides of such a single so-called "bi-polar" plate supply the fuel gas to the anode of one cell and the oxidant gas to the cathode of the adjacent cell.

For higher current density applications, particularly when operating on air as oxidant or with very large fluid flow field plates (active electrode areas of about 0.024 m^2 (0.25 ft^2) per cell) the single continuous channel

has limitations. The increased gas flow required for good performance on the cathode side results in a large pressure drop from the feed inlet to the exhaust outlet of the channel. It is thus desirable when operating on air to limit the pressure drop through the cell and thus minimize the parasitic power required to pressurize the air. Accordingly, several continuous separate flow channels are provided which traverse the plate typically in substantially the same serpentine manner.

Accompanying Figure 4 shows one preferred arrangement of a multiple channel flow plate according to another embodiment of this invention. As is seen, the major surface 42 has formed therein a number of flow channels (a few of which are identified as reference numeral 44) which follow a generally serpentine path between fluid supply and exhaust openings 45,47, respectively. Each channel 44 includes an inlet end 46 and outlet end 48 directly connected to the fluid supply and exhaust openings 45,47, respectively. As such, openings 45 and 47 are common to each of the channels 44. Although ten (10) individual channels 44 just happen to be shown in Figure 4, it will be understood that a greater/lesser number of channels 44 could be provided.

As will be apparent to those skilled in the art in the light of the foregoing disclosure, many alterations and modifications are possible in the practice of this invention without departing from the spirit or scope thereof. Accordingly, the scope of the invention is to be construed in accordance with the substance defined by the following claims.

Claims

1. A solid polymer electrolyte fuel cell in which, during use, liquid water is produced, including a fluid flow field plate made of a suitable electrically conducting material and having an open-faced fluid flow channel, a fluid supply opening and a fluid exhaust opening formed in a major surface thereof;

   characterised in that the plate includes multiple continuous fluid flow channels, each said channel traverses a major central area of said surface in a plurality of passes and has a fluid inlet at one end directly connected to said fluid supply opening and a fluid outlet at the other end directly connected to said fluid exhaust opening and each said channel includes a hydrophobic coating thereon, so that water produced during operation of the cell is urged through the fluid flow channels towards said fluid exhaust opening under pressure of the fluid in the channels.

2. A fuel cell according to Claim 1, wherein the channel follows a serpentine traversing path.

3. A fuel cell according to Claim 1 or Claim 2, wherein the channel traverses the major surface of the plate in a plurality of alternating closely spaced longer and shorter passes.

4. A fuel cell according to any one of the preceding Claims, wherein a channel is formed in both major surfaces of the plate.

5. A fuel cell according to any one of the preceding Claims, wherein the plate is a rigid non-porous graphite plate.

6. A fuel cell according to any one of the preceding Claims, wherein the channel comprises a base and opposing side walls diverging outwardly from said base toward said open-face.

7. A fuel cell according to Claim 6, wherein the base of the channel is flat.

8. A fuel cell according to any one of the preceding Claims, wherein the channel is of uniform depth throughout the length of the channel.

9. A fuel cell according to any one of the preceding Claims, wherein the hydrophobic coating is selected from the group consisting of polytetrafluoroethylene and silicone.

10. A fuel cell according to any one of the preceding Claims, comprising multiple separate continuous open-faced fluid flow channels, each channel having its own respective fluid inlet and outlet directly connected to said fluid supply opening and to said fluid exhaust opening, respectively.

11. A fuel cell according to any one of the preceding Claims, wherein the major central area of the plate is recessed to accommodate an electrode of said fuel cell.

12. A fuel cell according to Claim 11, wherein opposing plates in said fuel cell include matching recesses.

13. A fuel cell according to any one of the preceding Claims, wherein said major surface, adjacent channel passes are separated by lands.

14. A fuel cell according to Claim 13, wherein the lands are of a width less than the width of the open-face of the channel.

15. A fuel cell according to any one of the preceding Claims, wherein the width of the open-face of the channel is in the range of 0.076 to 0.610 cm (0.030 to 0.240 inches), and may be in the range of 0.102 to 0.254 cm (0.040 to 0.100 inches), and is advantageously in the range of 0.114 to 0.140 cm (0.045 to 0.055 inches), and is preferably about 0.127 cm (0.050 inches).

16. A fuel cell according to any one of the preceding Claims, wherein the land width is in the range of 0.025 to 0.508 cm (0.010 to 0.200 inches), and may be in the range of 0.051 to 0.254 cm (0.020 to 0.100 inches), and is advantageously in the range of 0.089 to 0.140 cm (0.035 to 0.055 inches), and is preferably about 0.102 cm (0.040 inches).

17. A fuel cell according to any one of the preceding Claims, wherein the suitable electrically conducting material is selected from the group consisting of graphite; a corrosion-resistant material, advantageously niobium; a base metal plated with a corrosion resistant metal; and a composite material composed of a corrosion-resistant metal powder, a base metal powder plated with a corrosion resistant metal or other chemically inert electrically conducting powders, advantageously 10-30%/w of polyvinylidene fluoride and 90-70%/w of graphite powder, bonded together with a suitable binder, advantageously polyvinylidene fluoride.

18. A fuel cell according to any one of the preceding Claims, wherein the channel depth is in the range of 0.025 to 0.635 cm (0.010 to 0.250 inches), and may be in the range of 0.076 to 0.381 cm (0.030 to 0.150 inches), is advantageously in the range of 0.102 to 0.203 cm (0.040 to 0.080 inches), and is preferably about 0.127 cm (0.050 inches).

19. A solid polymer electrolyte fuel cell according to any one of the preceding claims, the fuel cell further comprising:

an anode;

a cathode, and

a solid polymer electrolyte sandwiched between said anode and cathode; and wherein

an opposing pair of said fluid flow field plates are arranged in respective operative association with said anode and cathode, one of said field plates having a first fluid flow field adjacent said anode for supplying fuel thereto and exhausting reaction products therefrom, and the other of said field plates having a second fluid flow field adjacent said cathode for supplying an oxidant thereto and exhausting reaction products therefrom.

Patentansprüche

1. Eine Brennstoffzelle mit festem Polymerelektrolyt, bei der im Betrieb flüssiges Wasser erzeugt wird, umfassend eine Fluidströmungsfeldplatte aus einem geeigneten elektrisch leitenden Material mit einem seitlich offenen Fluidströmungskanal, eine Fluideinspeiseöffnung und eine Fluidaustragöffnung in einer Hauptfläche derselben;

dadurch gekennzeichnet, daß die Platte eine Mehrzahl kontinuierlicher Fluidströmungskanäle umfaßt, wobei jeder solche Kanal eine größere zentrale Fläche der Oberfläche in einer Mehrzahl von Durchgängen durchsetzt und einen Fluideinlaß an einem Ende aufweist, der direkt verbunden ist mit der Fluideinspeiseöffnung, und einen Fluidauslaß am anderen Ende aufweist, der direkt verbunden ist mit der Fluidaustragöffnung, und wobei jeder solche Kanal eine hydrophobe Beschichtung darauf aufweist, so daß Wasser, das im Betrieb der Zelle erzeugt wird, durch die Fluidströmungskanäle in Richtung der Fluidaustragöffnung getrieben wird unter dem Druck des Fluids in den Kanälen.

2. Eine Brennstoffzelle nach Anspruch 1, bei der der Kanal einem serpentinenförmigen Pfad folgt.

3. Eine Brennstoffzelle nach Anspruch 1 oder Anspruch 2, bei der der Kanal die Hauptfläche der Platte in

einer Mehrzahl von alternierenden, dicht benachbarten längeren und kürzeren Strecken durchsetzt.

4. Eine Brennstoffzelle nach einem der vorangehenden Ansprüche, bei der ein Kanal in beiden Hauptflächen der Platte ausgebildet ist.

5. Eine Brennstoffzelle nach einem der vorangehenden Ansprüche, bei der die Platte eine starre, nicht poröse Graphitplatte ist.

6. Eine Brennstoffzelle nach einem der vorangehenden Ansprüche, bei der der Kanal eine Basis und einander abgekehrte Seitenwandungen aufweist, die nach außen von der Basis in Richtung der offenen Seite divergieren.

7. Eine Brennstoffzelle nach Anspruch 6, bei der die Basis des Kanals flach ist.

8. Eine Brennstoffzelle nach einem der vorangehenden Ansprüche, bei der der Kanal von gleichförmiger Tiefe über die gesamte Länge des Kanals ist.

9. Eine Brennstoffzelle nach einem der vorangehenden Ansprüche, bei der die hydrophobe Beschichtung ausgewählt ist aus der Gruppe, bestehend aus Polytetrafluoräthylen und Silikon.

10. Eine Brennstoffzelle nach einem der vorangehenden Ansprüche, umfassend eine Mehrzahl getrennter kontinuierlicher, seitlich offener Fluidströmungskanäle, wobei jeder Kanal einen eigenen zugeordneten Fluideinlaß und -auslaß aufweist, welche direkt verbunden sind mit der Fluideinspeiseöffnung beziehungsweise der Fluidaustragöffnung.

11. Eine Brennstoffzelle nach einem der vorangehenden Ansprüche, bei der die zentrale Hauptfläche der Platte eingesenkt ist zur Aufnahme einer Elektrode der Brennstoffzelle.

12. Eine Brennstoffzelle nach Anspruch 11, bei der einander abgekehrte Platten in der Brennstoffzelle aneinander angepaßte Einsenkungen aufweisen.

13. Eine Brennstoffzelle nach einem der vorangehenden Ansprüche, bei der benachbarte Kanalstrecken der Hauptfläche von Zwischenflächen getrennt sind.

14. Eine Brennstoffzelle nach Anspruch 13, bei der die Zwischenflächen eine Breite aufweisen, die kleiner ist als die Breite der offenen Seite des Kanals.

15. Eine Brennstoffzelle nach einem der vorangehenden Ansprüche, bei der die Breite der offenen Seite des Kanals im Bereich von 0,076 bis 0,610 cm (0,030 bis 0,240 Zoll) ist, und im Bereich von 0,102 bis 0,254 cm (0,040 bis 0,100 Zoll) sein kann, und vorteilhafterweise im Bereich von 0,114 bis 0,140 cm (0,045 bis 0,055 Zoll) ist, und vorzugsweise etwa 0,127 cm (0,050 Zoll) ist.

16. Eine Brennstoffzelle nach einem der vorangehenden Ansprüche, bei der die Zwischenflächenbreite im Bereich von 0,025 bis 0,508 cm (0,010 bis 0,200 Zoll) ist, und im Bereich von 0,051 bis 0,254 cm (0,020 bis 0,100 Zoll) sein kann, und vorteilhafterweise im Bereich von 0,089 bis 0,140 cm (0,035 bis 0,055 Zoll) ist, und vorzugsweise etwa 0,102 cm (0,040 Zoll) ist.

17. Eine Brennstoffzelle nach einem der vorangehenden Ansprüche, bei der das geeignete elektrisch leitende Material ausgewählt ist aus der Gruppe, bestehend aus Graphit; einem korrosionsfesten Material, vorteilhafterweise Niob; einem Basismetall, plattiert mit einem korrosionsfesten Metall; und einem Compositematerial, bestehend aus einem korrosionsfesten Metallpulver, einem Basismetallpulver, plattiert mit einem korrosionsfesten Metall- oder anderen chemisch inerten, elektrisch leitenden Pulvern, vorteilhafterweise 10 bis 30 Gew.-% von Polyvinylidenfluorid und 90 bis 70 Gew.-% Graphitpulver, gebunden mit einem geeigneten Binder, vorteilhafterweise Polyvinylidenfluorid.

18. Eine Brennstoffzelle nach einem der vorangehenden Ansprüche, bei der die Kanaltiefe im Bereich von 0,025 bis 0,635 cm (0,010 bis 0,250 Zoll) ist, und im Bereich von 0,076 bis 0,381 cm (0,030 bis 0,150 Zoll) sein kann, und vorteilhafterweise im Bereich 0,102 bis 0,203 cm (0,040 bis 0,080 Zoll) ist, und vorzugsweise etwa 0,127 cm (0,050 Zoll) ist.

19. Eine Brennstoffzelle mit festem Polymerelektrolyt nach einem der vorangehenden Ansprüche, wobei die Brennstoffzelle ferner umfaßt:

eine Anode;

eine Kathode, und

einen festen Polymerelektrolyt, der zwischen der Anode und der Kathode eingebettet ist; und bei der

ein einander abgekehrtes Paar der Fluidströmungsfeldplatten in entsprechender Wirkverbindung mit der Anode und der Kathode angeordnet ist, wobei eine der Feldplatten ein erstes Fluidströmungsfeld aufweist nahe der Anode für die Zufuhr von Brennstoff zu ihr und Austrag von Reaktionsprodukten aus ihr, und die andere der Feldplatten ein zweites Fluidströmungsfeld nahe der Kathode aufweist für die Einspeisung eines Oxidationsmittels in sie und Austrag von Reaktionsprodukten aus ihr.

Revendications

1. Pile à combustible à électrolyte polymère solide, dans laquelle de l'eau sous forme liquide est produite lors de l'utilisation et qui comprend une plaque distributrice de fluide en une matière électriquement conductrice appropriée et comportant un canal d'écoulement de fluide à face ouverte, une ouverture d'amenée de fluide et une ouverture d'évacuation de fluide ménagées dans une de ses surfaces principales;

caractérisée en ce que la plaque comporte de multiples canaux continus d'écoulement de fluide, que chacun desdits canaux traverse une zone centrale principale de ladite surface sous forme d'une série de passages et est munie, à une première extrémité, d'une entrée de fluide reliée directement à ladite ouverture d'amenée de fluide et, à l'autre extrémité, d'une sortie de fluide reliée directement à ladite ouverture d'évacuation de fluide et que chacun desdits canaux porte un revêtement hydrophobe de sorte que l'eau produite pendant le fonctionnement de la pile est poussée à travers les canaux d'écoulement de fluide vers ladite ouverture d'évacuation de fluide sous la pression du fluide des canaux.

2. Pile à combustible selon la revendication 1, dans laquelle le canal suit un trajet sinueux de traversée.

3. Pile à combustible selon la revendication 1 ou 2, dans lequel le canal traverse la surface principale de la plaque par une série de passages faiblement espacés les uns des autres, alternativement plus longs et plus courts.

4. Pile à combustible selon l'une quelconque des revendications précédentes, dans laquelle un canal est formé dans les deux surfaces principales de la plaque.

5. Pile à combustible selon l'une quelconque des revendications précédentes, dans laquelle la plaque est une plaque en graphite rigide non poreux.

6. Pile à combustible selon l'une quelconque des revendications précédentes, dans laquelle le canal comprend un fond et des parois latérales opposées qui divergent vers l'extérieur depuis le fond vers ladite face ouverte.

7. Pile à combustible selon la revendication 6, dans laquelle le fond du canal est plat.

8. Pile à combustible selon l'une quelconque des revendications précédentes, dans laquelle la profondeur du canal est uniforme sur toute la longueur du canal.

9. Pile à combustible selon l'une quelconque des revendications précédentes, dans laquelle le revêtement hydrophobe est choisi dans le groupe constitué par le poly(tétrafluoréthylène) et un silicone.

10. Pile à combustible selon l'une quelconque des revendications précédentes, comprenant de multiples canaux d'écoulement de fluide séparés continus à faces ouvertes, chaque canal possédant sa propre entrée et sa propre sortie respective de fluide reliées directement à ladite ouverture d'amenée de fluide et à ladite ouverture d'évacuation de fluide, respectivement.

11. Pile à combustible selon l'une quelconque des revendications précédentes, dans laquelle la zone centrale principale de la plaque est en retrait de façon à loger une électrode de ladite pile à combustible.

12. Pile à combustible selon la revendication 11, dans laquelle des plaques opposées de ladite pile à combustible comportent des évidements concordants.

13. Pile à combustible selon l'une quelconque des revendications précédentes, dans laquelle les passages de canaux adjacents de ladite surface principale sont séparés par des îlots.

14. Pile à combustible selon la revendication 13, dans laquelle la largeur des îlots est plus faible que la largeur de la face ouverte du canal.

15. Pile à combustible selon l'une quelconque des revendications précédentes, dans laquelle la largeur de la face ouverte du canal est dans la plage de 0,076 à 0,610 cm (0,030 à 0,240 pouce), et peut être dans la plage de 0,102 à 0,254 cm (0,040 à 0,100 pouce), et est de façon avantageuse dans la plage de 0,114 à 0,140 cm (0,045 à 0,055 pouce), et est de préférence d'environ 0,127 cm (0,050 pouce).

16. Pile à combustible selon l'une quelconque des revendications précédentes, dans laquelle la largeur d'îlot est dans la plage de 0,025 à 0,508 cm (0.010 à 0,200 pouce), et peut être dans la plage de 0,051 à 0,254 cm (0,020 à 0,100 pouce), et est de façon avantageuse dans la plage de 0,089 à 0,140 cm (0,035 à 0,055 pouce) et est de préférence d'environ 0,102 cm (0,040 pouce).

17. Pile à combustible selon l'une quelconque des revendications précédentes, dans laquelle la matière électriquement conductrice appropriée est choisie dans le groupe constitué par du graphite; une matière résistant à la corrosion, de façon avantageuse du niobium; un métal de base plaqué d'un métal résistant à la corrosion; et une matière composite composée d'une poudre d'un métal résistant à la corrosion, d'une poudre d'un métal de base plaqué d'un métal résistant à la corrosion ou d'autres poudres électriquement conductrices chimiquement inertes, de façon avantageuse de 10 à 30 % en poids de poly(fluorure de vinylidène) et de 90 à 70 % en poids de poudre de graphite, liés entre eux par un liant approprié, de façon avantageuse un poly(fluorure de vinylidène).

18. Pile à combustible selon l'une quelconque des revendications précédentes, dans laquelle la profondeur de canal est dans la plage de 0,025 à 0,635 cm (0,010 à 0,250 pouce), et peut être dans la plage de 0,076 à 0,381 cm (0,030 à 0,150 pouce), est de façon avantageuse dans la plage de 0,102 à 0,203 cm (0,040 à 0,080 pouce), et est de préférence d'environ 0,127 cm (0,050 pouce).

19. Pile à combustible à électrolyte polymère solide selon l'une quelconque des revendications précédentes, la pile à combustible comprenant en outre:

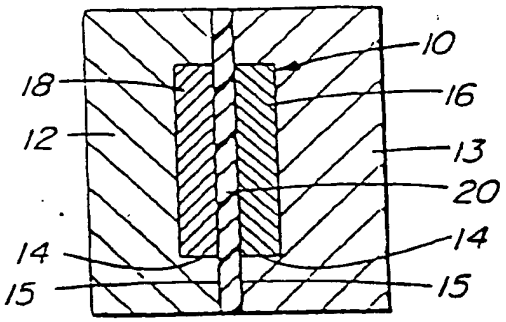
une anode;

une cathode, et

un électrolyte polymère solide pris en sandwich entre ladite anode et ladite cathode; et dans laquelle

une paire de plaques opposées parmi lesdites plaques distributrices de fluide est agencée en association de fonctionnement respective avec ladite anode et ladite cathode, l'une desdites plaques distributrices comprenant un premier champ d'écoulement de fluide près de ladite anode afin d'y amener un combustible et d'en évacuer des produits de réaction, et l'autre desdites plaques distributrices comprenant un deuxième champ d'écoulement de fluide adjacent à ladite cathode afin d'y amener un oxydant et d'en évacuer des produits de réaction.

FIG. 1



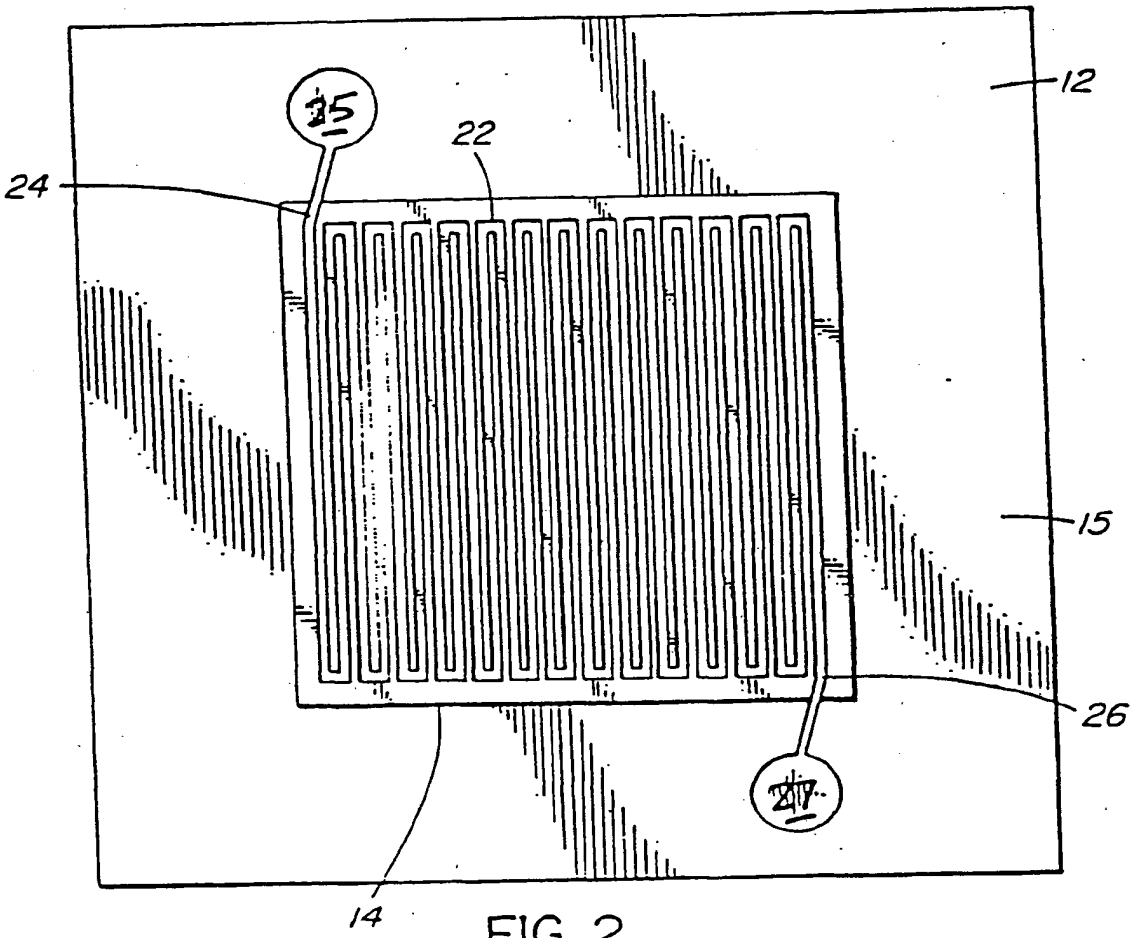
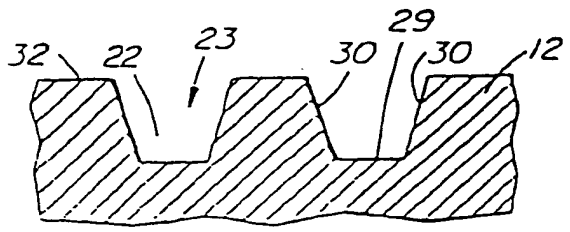


FIG. 2

FIG. 3



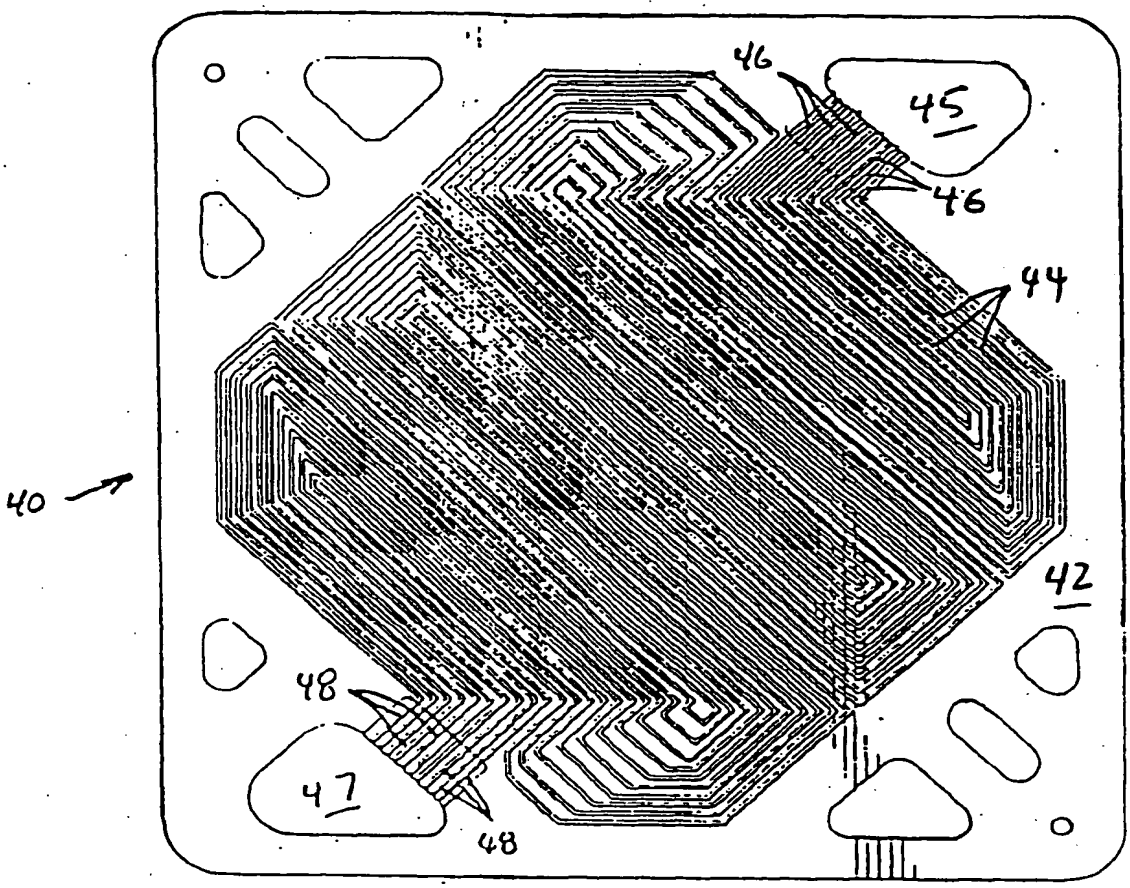


FIG. 4